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Instrument ofthe work breakdown accounting in the high-tech production

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Abstract. At present, in mechanical engineering there is a tendency of small-scale production due to the peculiarities and requirements of the market. At the same time, machine-building enterprises have to account the costs of produced products accurately (both for the state defense order and for the open market). The problem of the product labor intensity calculation becomes urgent, as it is used as a basis for of the product full cost calculation. Taking into account the technology changes, equipment, peculiarities of production program formation (small or medium series), using the existing approaches, work norms manuals becomes impossible. The investigation presents an improved algorithm for the work norm calculating using for the main workers in the high-tech production. A feature of the proposed approach is taking into account the share of passive observation during the technological operations in conditions of small-scale production in the conditions of the high-tech production. The article presents the results of the proposed method testing. The approbation was realized at the industrial enterprise in the conditions of the small-scale production. Proposed algorithm for work norms calculation can be used in automation of labor rationing at the industrial enterprise.

1. Introduction

The current state of Russia's economic system is characterized by an increase of the high-tech products share in the machine-building industry production structure. Machine-building enterprises face the necessity for increasing the share of civilian products in the production structure, which is achievable mainly through the development and sale of high-tech products. Thus, enterprises should not only organize production, but also ensure competitiveness of produced high-tech civilian products [1]. One of the competitive factors is the price [2], which is directly depends on the production costs of a particular product. The biggest part of the machine-building enterprises use product laboriousness or main part of the wages of the basic workers to calculate the cost of a product (for example, as a basis for the indirect costs dividing) [2, 3]. Another current trend is equipment replacement aimed at improving plant performance [4, 5]. In consideration of the foregoing premises, it has become necessary to update the approach of the work breakdown estimating, taking into consideration the peculiarities and capabilities of the new equipment and the changed organizational and technical conditions for the high-tech products production, and increased productivity [6,7]. The task of the main workers work quota setting system forming seems to be relevant. This system has to allow to objectively estimate the level of work breakdown for the high-tech products production in the production organization modern conditions. Thus, the purpose of this investigation was to form a work

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breakdown calculation approach for the high-tech products production according to the modern organizational and technological conditions.

2. Materials and methods

While the basic methods and tools of work quota setting are well known and widely used, it should be recognized that the current realities of production process organization, technology and equipment require the mainstreaming of work breakdown assessment approaches [8–12]. As a part of the investigation, a series of working time records was carried out, which revealed an increase of the equipment visual observation share in the work breakdown structure of the main worker during the high-tech products production.

It should be mentioned that the share of the equipment visual observation is steadily increasing as the production technical level improves [13, 14].

The total time of equipment visual observation is classified as [15]:

–time of active visual observation – time during which the worker closely observes the equipment, the process chart maintenance, the set parameters maintenance and the product quality. During this time, the worker does not perform physical work, but his presence in the workplace is mandatory;

–time of passive visual observation – time during which there is no need for constant visual observation of the equipment or the technological process, but the worker carries out it due to the lack of other work.

Reducing or using the passive visual observation time for perform other necessary work can be a significant reserve for improvement of productivity and labor efficiency [16].

During the worktime analyzing and the standard time calculating, the concepts of overlapping and non-overlapping time are also identified:

– the overlapping time – the equipment automatic operating time during which the worker realizes some operations (not related to the current process chart). Overlapped time can be direct manufacture time (active observation) and auxiliary time, as well as time related to the other worktime types;

– the non-overlapping time – time for auxiliary operation and workplace service operations (the equipment doesn't work).

The unit standard time consists of the necessary categories of worktime included in the calculation, taking into account the possibility of the additional works performing, rest time and personal needs (personal time), time for the workplace maintenance during the automatic operation of the equipment (the overlapping time).

The following formulas are used for standard time calculate within the proposed methodology.

The calculated unit standard time is presented per piece of product.

Batch is the number of products processed according to the process plan.

Billet – unit to be processed (can consist of several products).

$$T_{u-c} = T_u + T_p(N * n)^{-1} \tag{1}$$

T_{u-c} – the unit standard time for one produced unit, min.

T_u – the standard time for one produced unit, min.

T_p – preparatory time, min. for batch.

N – the number of procurements in the batch, pcs.

n – quantity of products in the billet, pcs.

$$T_u = T_c(1 + K_o * 100^{-1}) + T_c K_{in} \tag{2}$$

T_c – cycle time for one manufacturing operation, min.

K_o – the overlapping time coefficient, %. It takes into account the possibility of additional functions, rest time and personal needs (personal time), workplace maintenance, during the passive visual observation time. $K_o = 0$ if $K_1 > 1$

$$K_1 = T_o\left(T_a + T_m + T_p\right)^{-1} \tag{3}$$

T_a – time for additional work (includes necessary documentation filling, billet marking, work with the personal computer, etc.), min.

T_m – time for workplace maintenance, min.

T_p – rest time and personal needs (personal time), min.

If $K_1 \leq 1$ then the formula 8 is used.

$$K_o = T_a + T_m + T_p - T_{n-o} \quad (4)$$

For the coefficient calculation all parameters are taken as a percentage (%) of the cycle time.

K_{in} – coefficient taking into account the time of interruptions established by the technology and production process organization. It is calculated as a share of the time of interruptions established by the technology and production process organization in the cycle time.

3. Results

The proposed methodology was tested at the production site.

The standard time elements were used in the time calculating, this data are common for the investigated enterprise:

rest time and personal needs (personal time) – 6% to the cycle time;

workplace maintenance time – 5% to the cycle time.

Example 1. Based on the results of the working time records the following calculated data were obtained (table 1).

Table 1. Time by Category.

№	Type of time	Value, min.
1	Preparatory time for one batch (T_p)	15
2	The standard time for one produced unit (T_u)	The sum of points 2.1 и 2.2
2.1	Part-cycle time	According the cycle time
2.2	Auxiliary time	15
2.2.1	Auxiliary operation time	10
2.2.2.	Component inspection time	5
3	time for additional work (includes necessary documentation filling, billet marking, work with the personal computer, etc.) (T_a)	6.2
4	Time of interruptions established by the technology and production process organization	10% from the standard time

For this operation the ratio of active visual observation and passive visual observation is shown in table 2.

Table 2. Proportion of observations in % to part-cycle time.

Type of observations	Value
active visual observation	15
passive visual observation	85

Calculation of the norm per product is performed in accordance with the above procedure.

Table 3. Calculation of standard time per product.

№	Standard time element	unit of measure	Value
1	Preparatory time	min.	1.9
2	Quantity of products in the billet	pcs.	8
3	Standard time for one produced unit, including	min.	47.0
	Machine time	min.	32.0
	Auxiliary time	min.	15.0
4	Passive visual observation	min.	27.2
5	Passive visual observation share	%	57.9
6	Additional work time share	%	1.65
7	The overlapping time coefficient	–	0.00
	Checking the condition	%	4.58
8	Time of interruptions established by the technology and process organization	min.	4.70
9	Cycle time for one manufacturing operation	min.	51.70
10	The unit standard time for one produced unit	min.	53.58

The example 2.

The standard time elements were used in the time calculating:

rest time and personal needs (personal time) – 6% to the cycle time;

workplace maintenance time – 10% to the cycle time

Data of the investigated enterprise are given.

Based on the results of the working time records the following calculated data were obtained (Table 4).

Table 4. Time by Category.

№	Type of time	Value, min.
1	Preparatory time for one batch (T_p)	12
2	The standard time for one produced unit (T_u)	The sum of points 2.1 и 2.2
2.1	Part-cycle time	According the cycle time
2.2	Auxiliary time	12
2.2.1	Auxiliary operation time	8
2.2.2.	Component inspection time	4
3	time for additional work (includes necessary documentation filling, billet marking, work with the personal computer, etc.) (T_a)	18
4	Time of interruptions established by the technology and production process organization	10% from the standard time

For this operation the ratio of active visual observation and passive visual observation is shown in table 5.

Table 5. Proportion of observations in% to part-cycle time.

Type of observations	Value
active visual observation	60
passive visual observation	40

Calculation of the norm per product is performed in accordance with the above procedure.

Table 6. Calculation of standard time per product.

№	Standard time element	unit of measure	Value
1	Preparatory time	min.	12
2	Quantity of products in the billet	pcs.	1
3	Standard time for one produced unit, including	min.	62.0
	Machine time	min.	50.0
	Auxiliary time	min.	12.0
4	Passive visual observation	min.	20
5	Passive visual observation share	%	32.3
6	Additional work time share	%	29.03
7	The overlapping time coefficient	–	12.77
	Checking the condition	%	0.72
8	Time of interruptions established by the technology and production process organization	min.	7.44
9	Cycle time for one manufacturing operation	min.	77.36
10	The unit standard time for one produced unit	min.	89.36

4. Discussion

The article proposes an algorithm for standard time calculating for the main workers which takes into account the overlapped time. The generated algorithm allows to carry out calculations with a high degree of accuracy, taking into account the works performed during the machine time. The obvious advantage of this methodology (provided that the information system of the enterprise is used as a source of initial data) is the possibility to calculate standard time, duration rates, work breakdown individually for each detailed operation. It should be noted that the proposed methodology allows to ensure operativeness of calculations (when using automated calculation systems, for example, software).

The developed standard time mathematical model assumes the statistical data availability for estimation of the value of preparatory time in the established organizational technical conditions, as well as the rest time and personal needs (personal time) and the workplace maintenance. The existence of such a base, developed and adopted standards is undoubtedly a limitation for the rapid implementation of the methodology.

5. Conclusion

The high quality of standards and standard time applied in production enterprises ensures the efficiency of production organization and labor organization (the standard time is the basis for planning); remuneration organization of (the standard time is the basis for wage calculation); production planning; determination of production costs (the standard time is an indirect condition for indirect costs distribution). At the same time, most production enterprises use outdated standard time, which do not take into account changed organizational and technical conditions of production, capabilities of equipment, etc. Thus, the creation of a methodology for standard time calculating and ensuring the automation of its implementation will increase the efficiency not only of the production process, but also of the enterprise as a whole. The use of the proposed methodology will make it possible to increase the relevance and efficiency of organizational and economic data due to more

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accurate calculations, which in turn will affect the efficiency of the department and the enterprise as a whole.

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